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Opportunity for a fishery for Atlantic Saury (*Scomberesox saurus*) in the Nova Scotia portion of the southern Gulf of St. Lawrence

Opportunités de pêche au balaou (*Scomberesox saurus*) dans la partie néo-écossaise du sud du golfe du Saint-Laurent

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ABSTRACT

This document presents information on the biology and fisheries of Atlantic saury (*Scomberesox saurus*), with emphasis on the southern Gulf of St. Lawrence. It was prepared to address a request for a fishery for Atlantic saury in the Nova Scotia portion of the southern Gulf of St. Lawrence. Information is reviewed in relation to the objectives described in the DFO "POLICY ON NEW FISHERIES FOR FORAGE SPECIES". There are large knowledge gaps related to the biology, distribution and abundance of Atlantic saury in the southern Gulf of St. Lawrence. Little is known of the role of Atlantic saury in the ecosystem and in particular the importance of Atlantic saury as prey for marine organisms. With the possible exception of the gannets, there is no information at present to identify a predator species which is highly dependent on Atlantic saury. Based on general characteristics of the biology and ecology of Atlantic saury, it qualifies as a forage species under the definition of the policy. At present, there is no directed commercial fishery for Atlantic saury in Canadian Atlantic waters. The lack of information on stock structure and abundance precludes the derivation of reference points and assessment indicators against which to evaluate fisheries exploitation. As such, the biological and management prerequisites defined by the policy which would be required in order for fisheries on forage species to take place cannot be met. Properly collected information which could be obtained during exploratory fisheries would improve the knowledge of Atlantic saury and would benefit the development of a long-term management plan.

RÉSUMÉ

Le présent document résume les connaissances sur la biologie et les pêches au balaou (*Scomberesox saurus*) avec l'emphase sur le sud du golfe du Saint-Laurent. Cette revue a été préparée en réponse à une demande pour une pêche au balaou dans la région Néo-Écossaise du sud du golfe du Saint-Laurent. L'information est présenté par rapport aux objectifs décrits dans la politique du MPO intitulée « POLITIQUE SUR LA PÊCHE DES ESPÈCES FOURRAGÈRES ». Le manque de connaissances sur le balaou est très grave, y compris d'information de base sur la biologie, la distribution et l'abondance de cette espèce dans le sud du golfe du Saint-Laurent. On connaît très peu sur le rôle du balaou dans l'écosystème et en particulier son importance en temps que proie pour les organismes marins. À l'exception possible du fou de Bassan, aucune donnée ne permet actuellement d'identifier une espèce prédatrice qui soit extrêmement dépendante du balaou. Selon les caractéristiques biologiques et écologiques générales définis dans la politique, le balaou est une espèce fourragère. En ce moment, aucune pêche commerciale dirigée du balaou n'est pratiquée dans les eaux canadiennes de l'océan Atlantique. Grâce aux lacunes de connaissances sur la structure des populations et de l'abondance, on n'est pas en mesure d'établir des points de références ni des indicateurs d'état des stocks contre lesquels pourrait être évaluée l'exploitation dans les pêcheries. Les préalables biologiques et les préalables pour la gestion définis dans la politique nécessaires à une pêcherie sur une espèce fourragère ne sont pas comblés. Toute donnée qui pourrait être recueillie dans le cadre de pêches exploratoires favoriserait l'élaboration d'un plan de gestion à long terme.

INTRODUCTION

The increased value of crustacean fisheries (lobster, and snow crab) and the concomitant decline in a number of fisheries which traditionally provided bait for these fisheries (e.g. spring herring in the southern Gulf; LeBlanc et al. 2008) have motivated an interest by the fishing industry in alternate sources of bait. Interest has been shown for Atlantic silverside and Atlantic saury as sources of bait in the southern Gulf of St. Lawrence. Both of these species occupy lower trophic levels and are therefore potentially forage species of importance to several components of the aquatic ecosystem.

In response to the increasing interest in exploiting non-traditional marine species, Fisheries and Oceans Canada (DFO) developed a policy to guide the development of new fisheries and specifically in the context of fisheries on what are considered to be forage species (DFO 2009). The policy (POLICY ON NEW FISHERIES FOR FORAGE SPECIES) defines a forage species as:

> "...a species which is below the top of an aquatic food chain, is an important source of food for at least some predators, and experiences high predation mortality." (DFO 2009; p. 1)

A dependent predator is defined in the DFO policy as:

> "a species higher in the food web, which obtains a significant part of its annual food ration from the forage species, at least at times when the forage species is abundant. When the forage species declines markedly in abundance ... the dependent predator is likely to show biological responses." (DFO 2009).

Examples of historical fisheries on forage species include sardine, Atlantic herring, capelin, shrimp and euphausid fisheries (DFO 2009). In the context of sustainability, there have been no studies suggesting that the Canadian Atlantic fisheries for herring have resulted in noteworthy food limitation for the predators of herring (DFO 2009).

In 1995, DFO conducted a science review of a request for a krill fishery on the Scotian Shelf and the Bay of Fundy (DFO 1997). The review also provided guidance on conservation objectives for forage species fisheries and discussed under what fishery conditions the conservation objectives could be met. Based on this guidance document and the objectives defined in the forage species fisheries policy, the following terms of reference for the review of the opportunities for an Atlantic saury fishery in Gulf Nova Scotia area were developed:

- Describe the status of existing fisheries in the southern Gulf of St. Lawrence (licenses, locations, landings, gaps in information from the fishery).
- Provide an overview of the species biology and ecology. Does the species qualify as a forage species based on definitions in the "Policy on New Fisheries For Forage Species"?
- Under what conditions would a fishery be compatible with the "Policy on New Fisheries For Forage Species" and the previous science advice on forage species fisheries?
- Identification of knowledge gaps and recommended research to address these gaps.

This document was prepared to consolidate and present the relevant information on Atlantic saury in the Southern Gulf of St. Lawrence in order to address the terms of reference for a DFO Science Advisory Process on the opportunity for a fishery for Atlantic saury in the Nova Scotia portion of the southern Gulf of St. Lawrence (Dec. 15 – 16, 2009 in Moncton, NB). This document is structured to respond to the four objectives defined above although not in sequential order.

OVERVIEW OF THE BIOLOGY AND ECOLOGY OF ATLANTIC SAURY

The Atlantic saury (*Scomberesox saurus* Walbaum 1792) is a small, schooling pelagic fish with prolonged upper and lower jaws and an elongated body with a series of five to six finlets that extend between the dorsal fin and the caudal fin and between the anal fin and the caudal fin (Fig. 1).

Atlantic saury are distributed in the western Atlantic from Newfoundland to North Carolina. They are also found in the eastern North Atlantic, and in temperate waters of the South Atlantic (Scott and Scott 1988; Fig. 2). In Canadian waters they have been reported from the southern Gulf of St. Lawrence and off the coasts of New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland (Scott and Scott 1988; Collette and Klein-MacPhee 2002).

Collette and Klein-MacPhee (2002) considered Atlantic saury to be one of the most abundant epipelagic planktivoires that inhabit the open parts of the Atlantic Ocean (Fig. 2). They are broadly distributed in the temperate waters of the open ocean and are rarely observed over the continental shelf or in coastal areas except when surface temperatures are warmest (Scott and Scott 1988; Pohle et al. 1992; Collette and Klein-MacPhee 2002).

Virtually nothing is known about the stock structure of Atlantic saury but Pohle et al. (1992) suggested that the Atlantic saury that occur in waters off the east coast of Canada during the autumn are probably all members of a single stock.

Atlantic saury in the northwest Atlantic seem to prefer water temperatures between 8.2 and 24.8° C and undertake an annual migration northward in the late spring and summer and southward in the autumn associated with the warming and cooling of the surface waters (Dudnik et al. 1981) (Fig. 3). They also migrate diurnally between deeper depths (≤ 50 m) during daylight hours and shallow, near-surface depths at night.

Spawning occurs primarily during the winter and spring in the southern portion of its range in the Northern Hemisphere. Atlantic saury reach sexual maturity at a minimum size of 25 cm when most fish are between 2 and 3 years of age (Dudnik et al. 1981). The fertilized eggs, which are spherical, almost transparent and 2.5 – 3.2 mm in diameter, mature near the surface in water temperatures between 16.8 – 23.7°C. The larvae undergo metamorphosis when they reach a size of approximately 25 mm.

Nesterov (1974) concluded that Atlantic saury are fast growing and short-lived (maximum age not exceeding 4 years), being approximately 23 cm long at 2 years of age and 31 cm long at 3 years of age.

Collette and Klein-MacPhee (2002) contend that the great abundance of Atlantic saury and their wide distribution make them an important link in the epipelagic food chain of the ocean as they enable the transfer of energy from lower to higher trophic levels.

Atlantic saury feed almost exclusively on zooplankton with the sizes of organisms consumed varying with the size of the saury and the availability of prey items (Scott and Scott 1988). Siphonophores, copepods, euphausiids and amphipods are the most common prey consumed but fish eggs, larvae and occasionally small fish are also eaten (Nesterov and Shiganova 1976; Dudnik et al. 1981).

Atlantic saury have been reported as prey of a wide variety of predators including squid, swordfish, marlin, sharks, tuna, cod, hake, pollock, mackerel, dolphins, porpoises, whales and seabirds (Sergeant and Fisher 1957; Scott and Scott 1988; Collette and Klein-MacPhee 2002). However, most quantitative diet studies (other than those of gannets, see below) show Atlantic saury to be rare or absent as a prey component. No Atlantic saury were reported in a major compilation of fish and squid dietary data from the northeastern US (31,567 stomachs from 180 predator species; Bowman et al. 2000). Several groundfish diet studies in Canadian and US waters have not reported Atlantic saury as a prey item (Kohler and Fitzgerald 1969, Waiwood and Majkowski 1984, Garrison 2000). Atlantic saury have been reported from stomach samples of porbeagle shark (0.2% of sampled stomachs; Joyce et al. 2002) and the blue shark (present in 0.44% of sampled stomachs; McCord and Campana 2003) but in low abundance. There are anecdotal reports from fishermen (particularly recently) that bluefin tuna were observed feeding near the surface on "halfbeaks" (assumed to be Atlantic saury) (J. Nielson DFO, pers. comm.). However, 819 bluefin stomachs sampled from New England waters contained no saury (Chase 2002). Benoit and Bowen (1990) found Atlantic saury in the diet of grey seals from Sable Island but in low abundance (2 fish, 0.3% in frequency of occurrence, ranked 29 in prey importance). Atlantic saury was not reported as prey in numerous other dietary studies of seals in eastern Canadian waters (Fisher and MacKenzie 1955, Mansfield and Beck 1977, Boulva and McLaren 1979, Stewart and Murie 1986, Murie and Lavigne 1991, Stenson et al. 1991, Beck et al. 1993, Bowen et al. 1993, Lawson and Stenson 1995, Lawson et al. 1995, Bowen and Harrison 1996, Lawson and Stenson 1997, Hammill and Stenson 2000). There is little available information on the diet of whales in the northwest Atlantic although saury has been suggested as prey for dolphins as well as humpback whales. Fontaine et al. (1994) found no saury in harbour porpoises from the northwestern Gulf of St. Lawrence. Minke whales feed on saury in the western UK and Pacific saury (*Cololabis saira*) is prominent in the diets of a number of Pacific whale species (Jack Lawson, DFO pers. comm.).

Important variations in the importance of Atlantic saury in the diet of gannets have been observed (Montevecchi 2007). The diet of gannets (*Sula bassana*) has been sampled annually, generally from late July to mid-August, at the gannet colony of the Funk Islands (49° 45' N, 53° 11' W) off the northeast coast of Newfoundland. From 1977 to 1983, Atlantic saury was either not recorded or were a very minor component of the prey composition. In the mid- to late 1980s, saury was a major component. No saury were identified from diet samples in most years between 1990 and 2004 whereas in 2005 and 2006, 33% and 80% of the prey landed by the gannets were Atlantic saury (Table 1) (Montevecchi 2007). The variation in the importance of saury in the diet of gannets in late summer appears to be related to ocean temperatures which, when warm, favour a more northerly movement of temperate fishes like saury and hence an availability to gannets (Montevecchi 2007). Saury have also been sampled from gannet colonies in the Gulf of St. Lawrence but the proportion of the total diet comprised of saury was lower than in the gannet colony of the Funk Islands (Table 1). Lengths of saury sampled from gannet diets ranged from 34 to 42 cm fork length (Montevecchi et al. 2002). Cairns et al. (1991) estimated that gannets consumed over 2,000 t annually of Atlantic saury from the Gulf of St. Lawrence.

INFORMATION FROM RESEARCH SURVEYS ON THE DISTRIBUTION, ABUNDANCE AND SIZE COMPOSITION OF ATLANTIC SAURY

SURVEYS IN THE SOUTHERN GULF (NAFO DIV. 4T)

Annual Autumn Bottom-trawl Survey of the Southern Gulf (NAFO Div. 4T; 1971 - 2009)

This survey is a standardized bottom-trawl survey that has been conducted every autumn since 1971 in the southern Gulf of St. Lawrence (NAFO [Northwest Atlantic Fisheries Organization] Div. 4T). A stratified random survey design has been maintained, except for the period from 1984-1987, when randomly chosen fixed stations were surveyed. Stratification is based on depth and geographic area. The surveys are conducted in the month of September, before groundfish commence their migration out of the Gulf. Survey procedures and protocols were described by Koeller (1981), Hurlbut and Clay (1990), Benoît (2006), and Chadwick et al. (2007).

In the history of this survey, more than 5,500 valid tows were made, and only ten Atlantic saury were caught (Fig. 4). No patterns or trends are evident in the distribution of these catches (they were caught throughout the range of depths sampled). The Atlantic saury caught ranged in size from 17 to 35 cm and thus would be a mixture of sexually immature and mature animals (Fig. 5). The sampling gear used in this survey is not effective for capturing some pelagic fish like saury but regularly samples Atlantic herring, American shad and gaspereau (Benoît et al. 2003).

Annual Summer Bottom-trawl Survey of the Northumberland Strait (2000 - 2009)

A bottom-trawl survey has been conducted in the Northumberland Strait during July and August of each year since 2000 to evaluate American lobster abundance and recruitment. It also provides information on the distribution and abundance of other demersal fish and invertebrates. A stratified random design is used and standardized survey protocols are employed. For additional information on this survey see Hanson (2001) and Morin et al. (2002). The area surveyed has varied slightly each year but has consistently covered the central and western portions of the Northumberland Strait.

No Atlantic saury were caught in the history of this survey (2,074 tows; Fig. 6). The sampling gear used in this survey is likely not effective for capturing pelagic fish although herring, shad and gaspereau species are captured in the survey.

Annual Autumn Herring Acoustic Survey of the Southern Gulf (NAFO Div. 4T; 1990 - 2009)

An acoustic survey of herring concentrations has been conducted in the southern Gulf each autumn (September-October) since 1990. These surveys are usually concentrated in coastal areas (< 60 m) off the Chaleurs-Miscou area, north of P.E.I. and in some years, off Cape Breton (these are the traditional areas where NAFO Div. 4T herring aggregate in the fall). The survey design uses random parallel transects within strata. Sampling is carried out with a midwater trawl wherever major concentrations of herring are detected acoustically to determine species composition, biological characteristics and size distribution. For additional information see LeBlanc et al. (2008).

No Atlantic saury were caught in the history of this survey (535 tows; Fig. 7).

SURVEYS IN AREAS ADJACENT TO THE SOUTHERN GULF

Annual Summer Bottom-trawl Survey of the Northern Gulf (NAFO Div's. 4RST and 3Pn; 1990 - Present)

This survey is a standardized bottom-trawl survey that has been conducted every summer (August) since 1990 in the northern Gulf of St. Lawrence. A stratified random survey design is used and covers NAFO Div's. 4RS and the deep part (> 100 fathoms) of NAFO Div. 4T. Sub - Div. 3Pn was included from 1994 to 2003. Stratification is based on depth and geographic area. Survey procedures and protocols were described by Gagnon (1991), Hurtubise and Gagnon (1993), and Chadwick et al. (2007).

In the history of this survey, more than 4,200 valid tows were made and sixty-three (63) Atlantic saury were caught (Fig. 8). These catches were concentrated in the Laurentian Channel southeast of Anticosti Island and on Rose Blanche Bank south of Port-aux-Basques, NL (Fig. 8). Information on the size composition of these fish was not available.

Annual Summer Bottom-trawl Survey of the Scotian Shelf and Bay of Fundy (NAFO Div's. 4VWX and 5Zc; 1970 – 2009)

This survey is a standardized bottom-trawl survey that has been conducted every summer (July) since 1970 on the Scotian Shelf and in the Bay of Fundy. A stratified random survey design is used and covers NAFO Div's. 4VWX and 5Zc. Stratification is based on depth and geographic area. Survey procedures and protocols were described by Halliday and Koeller (1981) and Chadwick et al. (2007).

In the history of this survey, more than 6,500 valid tows were made, and only twenty-five (25) Atlantic saury were caught (Fig. 9). No patterns or trends are evident in the distribution of these catches (they were caught on the offshore banks and near the edge of the continental shelf). The Atlantic saury caught ranged in size from 14 – 33 cm, the majority of which would have been sexually immature (Fig. 10).

U.S. National Marine Fisheries Service Fall Bottom-trawl Survey (1963 - 2009)

This survey is a standardized bottom-trawl survey that has been conducted every autumn since 1963 off the northeast coast of the U.S. between Cape Hatteras, N.C. and the southern limits of the Scotian Shelf. A stratified random survey design is used and covers NAFO Div's. 5YZ, 6ABCDE and part of 4X. Stratification is based on depth, latitude and historical fishing patterns. Survey procedures and protocols were described by Azarovitz (1981) and Reid et al. (1999).

In the history of this survey (1963 to 2009), more than 14,000 valid tows were made, and Atlantic saury were caught in 168 of these tows, for a total catch of 358 fish (Fig. 11). No patterns or trends are evident in the generally wide distribution of these catches (they were caught on the offshore banks and near the edge of the continental shelf).

SALSEA Pelagic Ecosystem Survey of the Northwest Atlantic (Aug. 2008, September 2009)

An exploratory pelagic ecosystem survey was conducted in August 2008 and September 2009. The survey occurred off the east coasts of Newfoundland and southern Labrador and covered an area extending from just south of 49°N to 56°N, 49°W to 55°W in 2008 and into the Labrador

Sea (52° to 58°N) in 2009. An experimental pelagic trawl was used to characterize the abundance and distribution of pelagic fish within the upper 10 m of the water column (Fig. 12). The key species targeted by this survey was Atlantic salmon. Survey procedures and protocols were described by Chaput and Sheehan (2008).

Atlantic saury were the second most abundant species captured in this survey (by weight and percent of stations) with total catch during the surveys of 1,300 kg. The largest catches were made off the northern entrance to the Strait of Belle Isle (Fig's. 12 and 13). The fish ranged in size from 15 to 40 cm and there were modes in the length frequency at 27 and 34 cm in August 2008, and at 27 cm in September 2009, which would likely represent 2 and 3 year-olds, most of which would have been sexually mature (Nesterov 1974; Fig. 14). Individual weights of Atlantic saury varied from less than 50 grams at 25 cm length to over 150 grams at 35 cm length (Fig. 15).

Based on water temperatures, Atlantic saury were not caught at stations with surface temperatures (at about 10 m depth) less than 10°C (Fig. 13). A sea surface temperature composite for the western Atlantic for August 2008 shows that favourable temperatures (>= 10°C) extended into the Labrador Sea, off Newfoundland and Nova Scotia at that time (Fig. 3). Favourable temperatures also occurred in the Gulf of St. Lawrence by early August and they remained favourable until at least October in the eastern Gulf of St. Lawrence (Fig. 16).

INFORMATION FROM DIRECTED FISHERIES ON ATLANTIC SAURY

Dense aggregations of Atlantic saury have been reported by commercial fishermen and the media in the fall in some coastal areas of Atlantic Canada. One of the areas where this occurs on an almost annual basis is the Strait of Canso where large numbers of them strand on the shore, probably while fleeing predators, and die along the northern face of the causeway (Pohle et al. 1992).

An exploratory fishery for Atlantic saury has taken place over several years since 1995. In 1995, saury were captured with a mid-water pelagic trawl modified to fish at the surface in a very constrained area at Aulds Cove near the Canso causeway (MacAskill and Wood 1996). In that year, the fishery occurred from Nov. 14 to Dec. 1, indicating that saury are present late into the fall in this area.

The consistent reports of Atlantic saury in the eastern portion of the southern Gulf of St. Lawrence coincides with the generally warmer temperatures in this portion of the Gulf in the fall Sea surface temperatures in summer are favourable to Atlantic saury throughout the Gulf and this is reflected in the locations where saury were captured in bottom trawl surveys (Fig. 4).

DOES ATLANTIC SAURY QUALIFY AS A FORAGE SPECIES BASED ON DEFINITIONS IN THE "POLICY ON NEW FISHERIES FOR FORAGE SPECIES"?

The DFO policy on forage species fisheries identifies several characteristics of forage species. The biology and ecology of Atlantic saury is presented relative to these features and to assess whether Atlantic saury can be considered a forage species.

As per characteristics of forage fish defined in the "Policy on New Fisheries For Forage Species"	Atlantic saury
1. below the top of an aquatic food chain	Yes Atlantic saury feed on plankton and lower trophic levels
2. an important source of food for at least some predators	Yes Collette and Klein-MacPhee (2002) contend that Atlantic saury are an important link in the epipelagic food chain of the ocean as they enable the transfer of energy from lower to higher trophic levels. Known to be preyed upon by gannets, sharks and toothed whales in other parts of the Atlantic. The morphologically similar Pacific saury is consumed by toothed whales on the Pacific ocean
3. experiences high predation mortality	Yes Predation mortality rates have not been measured, but are likely high, given the species' short lifespan and small body size
4. fully recruits to the fishery at ages which still experience high mortality due to predation	Probably Atlantic saury are short-lived, of relatively small body size, and very likely experience high mortality due to predation at all ages
5. often undergoes large, natural fluctuations in abundance in response to environmental factors, on time scales comparable to or shorter than a generation	Probably Sporadic abundance in Canadian waters may reflect natural fluctuations in abundance due to environmental factors. The tendency to migrate to Canadian waters, including the Gulf of St. Lawrence, may vary substantially according to temperature regimes.
6. usually form dense schools for at least a part of the annual cycle	Yes
7. relatively short lived	Yes maximum age is reported at four years
8. have a coastal distribution for at least a part of the year	Yes as observed in the southern Gulf of St. Lawrence
9. often support dependent predators (which are species that obtain a significant part of their annual food ration from the forage species)	Probably In some years, saury is a high proportion of the late summer diet of gannets on Funk Island, NL. Available diet studies of fish and marine mammals suggest that saury are a negligible fraction of the diet of these animals

Based on these characteristics, Atlantic saury qualifies as a forage species.

STATUS OF EXISTING FISHERIES IN THE SOUTHERN GULF OF ST. LAWRENCE

Atlantic saury are the object of valuable food-fisheries in certain parts of the world (Collette and Klein-MacPhee 2002). The Pacific saury (*Cololabis saira*) supported a major fishery in the northwestern Pacific with landings of approximately 300,000 t per year during the late 1980's (FAO 1990). In the past, the Atlantic saury was reported to be a delicious food when canned and more recently has been used as bait in commercial fisheries.

Atlantic saury represent a negligible part (less than 5%) of the total catch of saury species (Atlantic and Pacific) which has ranged between about 200 thousand to 600 thousand tons annually (Maguire et al. 2006). Sauries are not a species of direct interest for international fisheries bodies and although their state of exploitation is not known, sauries are unlikely to be overexploited (Maguire et al. 2006).

Fisheries for Atlantic saury off the eastern United States are not large and annual landings are sporadic. A query of the National Marine Fisheries database was conducted over the available years 1950 to 2007 under the species names "billfishes", "skippers", and "Atlantic needlefish". The first recorded landings in the database are from 1963. There appears to have been a change in species coding: in the initial part of the database, landings were recorded primarily as "billfishes", and since 1986, the entries have been recorded mostly as "skippers". The annual reported landings (1963 – 2007) ranged from less than 1 t to 37 t (Table 2).

At present, there is no directed commercial fishery for Atlantic saury in Canadian Atlantic waters but there have been numerous attempts to exploit this species in the past. Scott and Scott (1988) suggested that many of these attempts were hampered by the sporadic abundance of Atlantic saury in Canadian waters.

Prior to the 1950's, experimental fishing for this species was conducted in St. Margaret's Bay, NS where mackerel traps had yielded catches in certain years as high as 4.5 – 6.8 tonnes per trap (Scott et al. 1974). Trials were made using drift gill nets, lift nets and artificial light, and Day (1950) provided recommendations for future work. From 1969 – 1974, experimental fishing was conducted by the U.S.S.R. in the northwest Atlantic using nets suspended from booms (Dudnik et al. 1981). Reported annual landings by foreign vessels (mainly Russian) fishing in this area for the years 1970 – 1975 ranged from 490 – 3,429 t (Scott and Scott 1988).

Commercial landings were obtained from NAFO and ZIFF (Zonal Interchange File Format) data files. Atlantic saury were recorded in ZIFF as 'billfish' (code 260) and as 'Atlantic saury' (code 220) by NAFO.

In the NAFO data files (1960 - 1999), the only year with any reported landings of Atlantic saury in the southern Gulf (NAFO Div. 4T) was 1987 when 1.0 t was recorded landed in the month of October. There were no reported landings of Atlantic saury in NAFO Div's. 4RSVWX in the ZIFF data files (1985 – Present; Table 3). Since 1985, the total reported landings for NAFO Div. 4T in the ZIFF data files were less than 300 t and they were very erratic (occurred in less than one quarter of the years since 1984). There have not been any reported landings since 2001. All of the reported landings were landed in Aulds Cove, NS (Table 4). The ZIFF data files indicate that a variety of fishing gears contributed to these landings: fixed trap (FPN) in 1987, pair seine (SPR) from 1995 – 1997 and in 2001, and fixed gill nets (GNF) in 1999. They also indicate that no more than three vessels contributed to the landings in any of the years. The majority of the reported landings (88%) were made during the month of November.

Fishermen report catches of Atlantic saury in the Aulds Cove area of St. George's Bay, most often associated with meshing in mackerel trapnets. In fact, meshing of saury in trapnets has reportedly resulted in the gear sinking and being rendered unusable for weeks at a time (D. MacAskill, pers. comm.).

Since the mid-1980's, there have been several efforts to develop a fishery for this species in Aulds Cove off the north side of the Canso Causeway, in St. Georges Bay. Unfortunately, with one exception, little has been learned from these efforts that would assist harvesters or managers attempting to demonstrate the potential for a directed fishery for this species. The exception was an experimental fishery conducted from Nov. 14 to Dec. 1, 1995 in which permits were issued to two individuals to use a pelagic mid-water trawl (pair seining) to fish for Atlantic saury. The pelagic mid-water trawl had the following dimensions and mesh sizes (MacAskill and Wood 1996):

Horizontal opening	19.8 m	Mesh in wings	150 mm
Vertical opening	6.09 m	Mesh in body	60 mm
Head rope length	15.84 m	Mesh in codend	15 mm
Foot rope length	15.84 m		
Cod end length	12.18 m		

During the experimental fishing, the mid-water trawl was modified to fish at the surface and 85 fishing sets were completed on the northwest side of the causeway. This fishing effort yielded 39.7 t of Atlantic saury. The proponents of this experimental fishery produced a report (MacAskill and Wood 1996 - Unpublished) describing the results of their project and provided set-specific information on catches, and effort (duration of tow). They provided a description of the gear that they used and how they modified and used it.

The tows were of short duration, 56 of 85 sets had tow durations between 15 and 30 minutes, with the longest tow of 50 minutes (MacAskill and Wood 1996). Of the 85 sets, 15 resulted in no catch of saury and 23 sets produced catch rates of > 500 kg per 15 minute tow (Fig. 17). The proponents indicated that their catch rates were highest after dark but that they also had good catches during daylight hours (MacAskill and Wood 1996). The authors are correct in that Atlantic saury were most often caught after dark but the highest catch rates occurred during daylight tows (Fig. 17). Catch rates were highest at the start of the fishing experiment and decreased into the end of November (Fig. 17), the fish having presumably moved out of the area as water cooled (MacAskill and Wood 1996).

MacAskill and Wood (1996) indicated that their bycatch for the entire experiment did not exceed 10 kg, was recorded from 6 of 85 sets, and was composed of threespine sticklebacks, rainbow smelt, capelin and a few alewife (that rarely exceed 5 cm in length and weighed less than 1.0 kg in total). Ultimately, they recommended that "such a fishery looks promising but we must conclude that our efforts in 1995 have simply not provided adequate information to reach any useful conclusions about the fishery". Subsequent years landings from this exploratory fishery were 4 t in 1996, 57 t in 1997 and 176 t in 2001 (Tables 3 and 4).

Information on the size composition of Atlantic saury was provided by the proponents during the 1995 fishery (Fig. 18). As well, two length frequency samples were obtained by a DFO port

sampler on Nov. 2 and Nov. 15, 2001 from the Aulds Cove fishery (Fig. 19). In the 1995 data, there are two modes, one at 31 cm and the other at 34 cm. In both length frequencies from the 2001 fishery, there is a prominent mode at 28 cm and a second much smaller one at around 34 cm which would probably correspond to 2 and 3 year-olds, most of which would have been sexually mature.

GAPS IN INFORMATION FROM THE FISHERY

- There has been only a limited exploratory fishery for Atlantic saury in the southern Gulf of St. Lawrence since 1995. Catch statistics are very erratic, with catches reported in less than one quarter of the years since 1984. As well, there are no reported landings since 2001. Although exploratory fishing was carried out after 2001, no catches were taken (D. MacAskill and A. Anderson, pers. comm.). No exploratory license was issued in 2008 or 2009.

- According to the catch statistics, the most important reported landings have been made by pair-seine. This may be a coding issue (i.e. the gear code assigned to this fishing gear may be incorrect). The exploratory fishery, as reported by MacAskill and Wood (1996), used a pelagic mid-water trawl to fish at the surface and was towed usually by two boats (paired trawling). Landings of Atlantic saury have also been recorded as coming from gillnets and trap (fixed). The correctness of these codings is not known.

- During the 1995 fishery, the proponents experimented with trawl configurations and settings. So the catch rates from 1995 may not be the same as those in subsequent years when the appropriate configuration had been found. Information on trawl dimensions and configurations will be essential in the future if the fishery develops and catch rate indices become available and hopefully comparable.

- Detailed (i.e. set-by-set) information from individual sets is available for the 1995 exploratory fishery. Detailed data for other years are not available. Additional data which would be useful for analyzing catch rates as indicators of relative abundance would be exact location, depth, light intensity, surface temperature, etc., (data which are typically part of science monitoring programs for other species groups).

- Size and sex composition of Atlantic saury during the fishery and data on bycatch would be required.

UNDER WHAT CONDITIONS WOULD A FISHERY BE COMPATIBLE WITH THE "POLICY ON NEW FISHERIES FOR FORAGE SPECIES" AND THE PREVIOUS SCIENCE ADVICE ON FORAGE SPECIES FISHERIES?

DFO (2009) defines the following (5) objectives of a conservation-based policy on commercial fisheries for forage species as:

- maintenance of target, bycatch, and ecologically dependent species within the bounds of natural fluctuations in abundance;

- maintenance of ecological relationships among species affected directly or indirectly by the fishery within the bounds of natural fluctuations in these relationships;

- minimization of the risk of changes to species' abundances or relationships which are difficult or impossible to reverse;

- maintenance of full reproductive potential of the forage species (including genetic diversity and geographic population structure, whether genetically resolvable or not);

- allowance of opportunities to conduct commercially viable fisheries.

As a general policy, commercial fisheries on forage species will be permitted on Canadian stocks, but only when there is a reasonable expectation that the five overall objectives would be met (DFO 2009). Several biological and management system prerequisites would be considered to determine if there is a reasonable expectation of achieving the conservation objectives.

BIOLOGICAL PREREQUISITES

1. "It should be possible to estimate some metrics of the status of the forage species on a regular basis, and there must be some values of those metrics against which achievement of conservation can be judged. In all cases, fisheries should not cause populations (or biological characteristics) of forage species or their predators to fluctuate outside the normal range of variability of the populations" (DFO 2009).

Examples of possible metrics for assessing the status of the forage species include age composition (relative to unexploited state), and mature biomass relative to unexploited biomass (DFO 2009).

- The science knowledge is currently insufficient to develop such metrics. In the case of Atlantic saury, there is no information on which to assess the biomass of the species in the western Atlantic nor the proportion of that biomass which enters the Gulf of St. Lawrence and is available to the fisheries. The long-term, marine monitoring programs of DFO have targeted demersal species and the gear used in these surveys are not suitable for sampling upper water column pelagic species such as the Atlantic saury. We found no relevant information from fisheries on Atlantic saury in the western Atlantic. The only published scientific work on Atlantic saury in the western Atlantic dates to the 1970s (Nesterov 1974, 1979). Based on surveys by Russian vessels in the early 1970s, Nesterov (1979) suggested that the biomass of Atlantic saury in the western Atlantic could have been as high as 900 thousand tons, with an annual catch potential of 340 to 380 thousand tons. Other than anecdotal reports of sporadic catches, and strandings, there are no indicators of Atlantic saury abundance for the Gulf of St. Lawrence. However, data from developing fisheries, should these occur, could be collected and potential metrics developed.

2. "It should be possible to identify some species of predators which would be appropriate for evaluating the sustainability of the fishery in the context of ecologically related species" (DFO 2009).

> "Species which are most sensitive to the abundance of the forage species would be most appropriate for evaluating the ecosystem sustainability of the fishery. The underlying assumption is that if a fishery on a forage species is being managed such that conservation of ecologically related species of high sensitivity

are being conserved, conservation of less sensitive species is even less likely to be put at risk by the fishery" (DFO 2009).

- As a small-bodied, pelagic fish which spends a substantial amount of time in the upper 10 metres of the water column, it is likely preyed upon by a variety of predators, including large pelagic fish such as tuna, various seabirds, dolphins, and whales. Atlantic saury has been reported in low abundance from stomach samples of two shark species in the western Atlantic. The importance of Atlantic saury in the diet of bluefin tuna is unknown but tuna are present in the Gulf of St. Lawrence in late summer and fall, and Atlantic saury are likely prey for these fish. In many years, and conditional on ocean temperatures, Atlantic saury have comprised a high proportion of the diet of gannets off the northeast coast of Newfoundland (Montevecchi 2007). There is no evidence in the science literature of Atlantic saury being such a dominant component of the diet of a predator that the predator species could be harmed by competition for the resource from commercial fishing. In this context, there is no corresponding predator species which could be monitored in relation to the fishery exploitation.

3. "It should be possible to estimate the risk that the proposed level of harvest poses to the forage species and ecologically dependent species" (DFO 2009).

- There is no information, even on the relative abundance of Atlantic saury in the western Atlantic and specifically for the southern Gulf, to conduct a risk assessment even in a qualitative sense.

4. "There should be sufficient knowledge of the forage species and its relationships to major marine predators to guide the proper prosecution of the fishery in space and time" (DFO 2009).

- As indicated in the previous paragraphs, there is insufficient knowledge of Atlantic saury in the western Atlantic and in the Gulf of St. Lawrence with which to assess the fishery potential and its consequences on the ecosystem. Any fishery which develops should have a well defined sampling protocol in order to gather such baseline information.

MANAGEMENT PREREQUISITES

1. "Consistent with the precautionary approach, there should be clearly identified conservation (limit) reference points and associated harvest control rules, for measurable properties of both the forage species (see 5.1.1) and some dependent marine predators (see 5.1.2)" (DFO 2009).

- The present knowledge is insufficient to develop biomass reference points for Atlantic saury. Proxy limit reference points for the fishing rate could be proposed. Such a proxy could be that the fishing rate should not exceed the natural mortality (M) rate. Atlantic saury is a short-lived species (maximum age of about four years) and is expected to have a high M. Nesterov (1974) suggested M was 1.5. Hoenig (1983) proposed the intuitive premise that the longevity and mortality rate in a species should be inversely related since animals from a population with high mortality would not be expected to reach an old age. Hoenig described a relationship relating mortality (Z or M) to maximum age. At a maximum age of 4 years for Atlantic saury, M = 1. On that basis, maximum fishing rate for Atlantic saury would be F = 1, or an annual exploitation rate of 65%.

2. "For the reference points and harvest control rules to be able to ensure conservation is achieved, monitoring and enforcement must be adequate to ensure high compliance with the management plan occurs, and is seen to occur" (DFO 2009).

- As stated previously, there are no biomass reference points which can presently be defined. Although a proxy fishing rate reference point could be developed, there are no measures of abundance against which catches can be assessed.

3. "Because of the need for visible and high compliance of commercial fisheries with all provisions of the management plans, and for extensive and reliable monitoring of both the forage species and often selected predators, management costs for these fisheries are expected to be high. Industry proponents and participants have a responsibility to carry a fair share of the incremental costs of management" (DFO 2009).

- The current knowledge of Atlantic saury in the western Atlantic and the Gulf of St. Lawrence is so scant that any information on biology, distribution, and relative abundance which would be obtained during the development of Atlantic saury fisheries would benefit the development of management processes consistent with the conservation objectives on forage species.

4. "Management plans for fisheries on forage species should include explicit provisions to ensure that fisheries do not unduly lead to local depletions of the forage species for time scales long enough to have consequences for predators" (DFO 2009).

- The presence and relative abundance of Atlantic saury in the eastern side of the southern Gulf of St. Lawrence is likely associated with warm temperatures in that part of the Gulf as well as the abundance of the western Atlantic stock of Atlantic saury. Local knowledge indicates that Atlantic saury are variably abundant in Aulds Cove, NS depending on the year. These variations in perceived abundance are observed in the absence of any directed fisheries of any consequence on Atlantic saury in the western Atlantic. The present knowledge is insufficient to determine the causes of the variation in abundance of Atlantic saury in the southern Gulf.

5. "Limitation of bycatch and impacts on habitats often should be important components of Management Plans for forage species" (DFO 2009).

- The experience of the fishermen who conducted exploratory fishing for Atlantic saury in St. George's Bay, NS indicates that the mid-water trawl modified for fishing at the surface resulted in minimal bycatch of other species, at least in November 1995 (MacAskill and Wood 1996). The level of bycatch would depend upon when fishing occurred. If pelagic trawling was to occur earlier, bycatch of herring, mackerel, jellyfish as well as leatherback turtles could be expected; leatherback turtles are known to occur in the St. George's Bay area in the fall of the year (James et al. 2006). The impact on habitat would be negligible as the pelagic gear does not touch the bottom. Atlantic saury have also been reported from mackerel trapnets in the Aulds Cove area but the mesh size of the mackerel trapnets is such that it results in meshing of saury which causes grief to the fishermen. Trapnets would have a greater potential for bycatch and habitat impacts than the pelagic surface trawl which has been used previously.

6. "Management of commercial fisheries on forage species should include long-term plans which delineate the expected sizes of the fleet and harvests over several years, specify the

long-term strategic objectives for the fishery, as well as the annual (or short-term) operational objectives within which the fishery will operate, and the harvest control rules which will guide and constrain operations" (DFO 2009).

- Prudent development of the fishery during the initial years when scientific and fisheries data can be collected would be consistent with this condition.

CONCLUSION

There is such a paucity of information on Atlantic saury in the western Atlantic and the southern Gulf of St. Lawrence that any information which can be obtained during exploratory fisheries would benefit the development of a long-term management plan. With the possible exception of the gannet, there is no information at present to identify a predator species which is highly dependent on Atlantic saury and which could be harmed by a slowly developing Atlantic saury fishery.

IDENTIFICATION OF KNOWLEDGE GAPS AND RECOMMENDED RESEARCH TO ADDRESS THESE GAPS

There is a very large knowledge gap for Atlantic saury which relates to basic information on biology, distribution and abundance in the southern Gulf of St. Lawrence. The long-term, marine fish monitoring programs at DFO are directed at demersal fish stocks and do not use gears appropriate for sampling pelagic fish like Atlantic saury which spend most of their time in the upper part of the water column. Atlantic saury can be captured in surface pelagic trawls (as demonstrated by the SALSEA survey) during the day. Day / night effects on catchability would need to be examined.

Detailed, fishery-dependent data would also be required. This would include detailed (i.e. set-by-set) information on catch, effort (time trawled), location, and associated environmental parameters (time, light intensity, surface temperature, etc.). Fishing according to a research protocol that would allow the development of standardized catch rates should be considered. Such fishing protocols have been developed for the sentinel fisheries program in the Gulf. The time of year when saury are present and where it is present in the southern Gulf is poorly known. This gap could be addressed by designing exploratory fishing over a longer season (Sept. 1 to Dec. 1 for example) and over a larger area than has been realized to date.

Biological characteristics data including size, weight, sex, scales or other tissue for ageing should be collected from the fishery.

Little is known of the role of Atlantic saury in the ecosystem and in particular of the importance of Atlantic saury as prey for marine organisms. Observations of the presence and activities of tuna, porpoises, whales, turtles and seabirds in the vicinity of fishing operations relative to Atlantic saury catches would begin to address this knowledge gap.

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Table 1. *Percentage of Atlantic saury in the diet of northern gannets in eastern Canada. Bonaventure Island and Bird Rocks are gannet colonies in the central Gulf of St. Lawrence.*

Year	Bonaventure Island (Gaspé) [1]	Bird Rocks (Magdalen Islands) [2]	Funk Island (Newfoundland) [3]
1966	0		
1967	0		
1968	0		
1977		0	0
1978		0	10
1979			8
1980			4
1982			1
1983			4
1984			54
1985			39
1986			4
1987		5	19
1988		27	44
1989			63
1990			0
1991			1
1992			0
1993			0
1994			12
1995	0		0
1996			0
1997			3
1998			12
1999			10
2000			0
2001			1
2002			3
2003	0		0
2004			2
2005			33
2006			80
Mean	0	8	14

[1] Data from Poulin 1968, Lafleur 1969, Rail et al. 1996, and Garthe et al. 2007

[2] Data from Burton 1980, Cairns et al. 1991, and D. Cairns (DFO unpubl.)

[3] Data from Garthe et al. 2007, Montevecchi 2007, and Montevecchi et al. 2009

Table 2. *Landings (t) data from the Atlantic states of the eastern United States based on a query of the National Marine Fisheries Service database. Queries were done for billfish, skipper and Atlantic needlefish. No data were returned for the query Atlantic saury. The period covered was 1950 to 2007. The database can be queried at: www.st.nmfs.noaa.gov/pls/webpls/FT_HELP.SPECIES.*

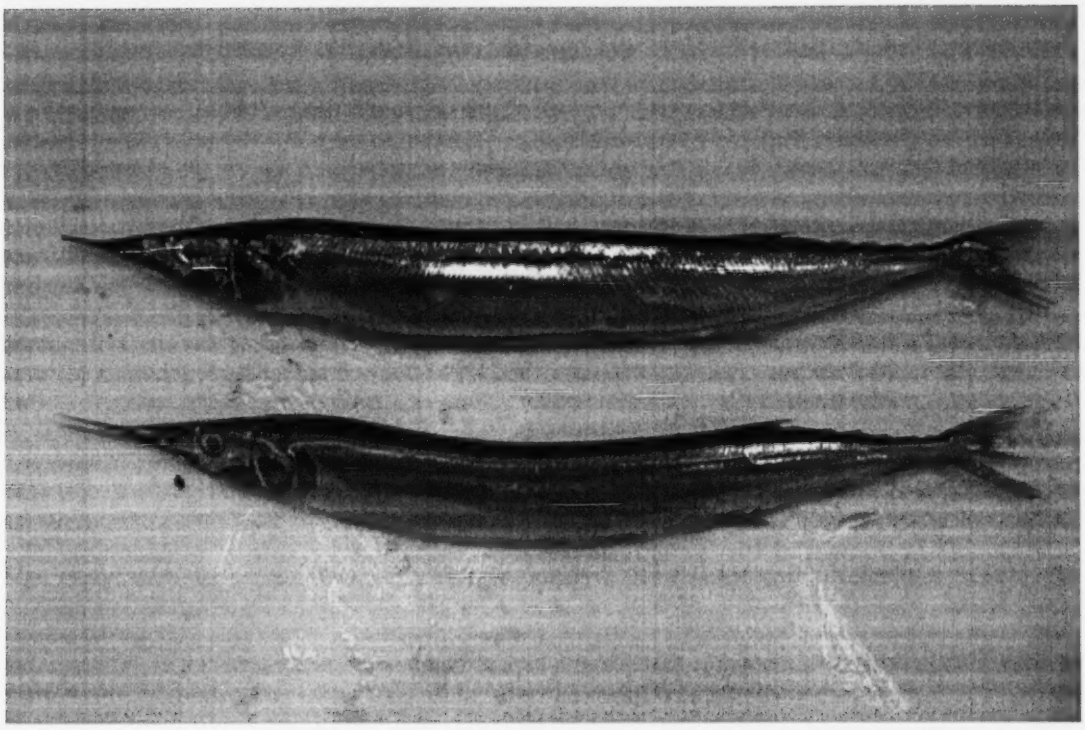
Year	Billfishes	Atlantic needlefish	Skippers	Total all names
1963		2.4		2.4
1964	0.2	0.1		0.3
1965	0.3			0.3
1966		2.9		2.9
1967		0.2		0.2
1969	0.0	0.0		0.0
1970		0.0		0.0
1973		0.5		0.5
1978	0.2			0.2
1979	11.3			11.3
1981	20.2			20.2
1982	15.6			15.6
1983	14.2			14.2
1984	44.1			44.1
1985	37.0			37.0
1986	6.4		9.3	15.7
1987	7.9		10.3	18.2
1988	1.9		4.2	6.1
1989			14.1	14.1
1990			10.0	10.0
1991			13.1	13.1
1992			11.2	11.2
1993	0.0		6.9	6.9
1994	0.2		12.5	12.7
1995			12.2	12.2
1996		0.0	16.8	16.8
1997			16.7	16.7
1998			14.9	14.9
1999		0.0	8.2	8.2
2000		0.0	10.1	10.1
2001			12.2	12.2
2002			15.8	15.8
2003		0.0	9.9	9.9
2004			4.2	4.2
2005			5.8	5.8
2006			6.0	6.0
2007			5.7	5.7

Table 3. *Reported landings (tonnes) of Atlantic saury (code 260) from NAFO Divisions 4RSTVWX from ZIFF data files.*

Year	4R	4S	4T	4V	4W	4X
1985	0.0	0.0	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.0	0.0	0.9	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	43.5	0.0	0.0	0.0
1996	0.0	0.0	3.7	0.0	0.0	0.0
1997	0.0	0.0	59.2	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.3	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	175.9	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0	0.0	0.0
2003	0.0	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0	0.0
Totals	0.0	0.0	283.5	0.0	0.0	0.0

Table 4. *Disaggregated reported landings (tonnes) of Atlantic saury (code 260) from NAFO Division 4T for the period 1985 to 2008 from ZIFF data files.*

Year	Month	Vessel	Gear	Port_Land	Main_Sp Sought	Main_Sp Caught	Landed kgs
1987	10	Vessel A	FPN - Trap - Fixed	Aulds Cove, NS	Not Specified	A_Saury	909
1995	11	Vessel B	SPR - Pair Seine	Aulds Cove, NS	Not Specified	A_Saury	21770
1995	11	Vessel C	SPR - Pair Seine	Aulds Cove, NS	Not Specified	A_Saury	21770
1996	11	Vessel B	SPR - Pair Seine	Aulds Cove, NS	Not Specified	A_Saury	1837
1996	11	Vessel C	SPR - Pair Seine	Aulds Cove, NS	A_Saury	A_Saury	1815
1997	11	Vessel C	SPR - Pair Seine	Aulds Cove, NS	Not Specified	A_Saury	29605
1997	11	Vessel D	SPR - Pair Seine	Aulds Cove, NS	Not Specified	A_Saury	29606
1999	10	Vessel E	GNF - Gillnet - Fixed	Aulds Cove, NS	Not Specified	Mackerel	99
1999	10	Vessel F	GNF - Gillnet - Fixed	Aulds Cove, NS	Not Specified	Mackerel	99
1999	10	Vessel G	GNF - Gillnet - Fixed	Aulds Cove, NS	Not Specified	Mackerel	98
2001	11	Vessel D	SPR - Pair Seine	Aulds Cove, NS	A_Saury	A_Saury	74225
2001	11	Vessel H	SPR - Pair Seine	Aulds Cove, NS	A_Saury	A_Saury	67803
2001	12	Vessel H	SPR - Pair Seine	Aulds Cove, NS	Not Specified	A_Saury	33879



Scientific name:	*Scomberesox saurus* Walbaum 1792
Family:	Scomberesocidae
Common names:	Atlantic saury, saury, billfish, skipper (English) Balaou (French)

Figure 1: *Taxonomy of Atlantic saury (Scomberesox saurus).*

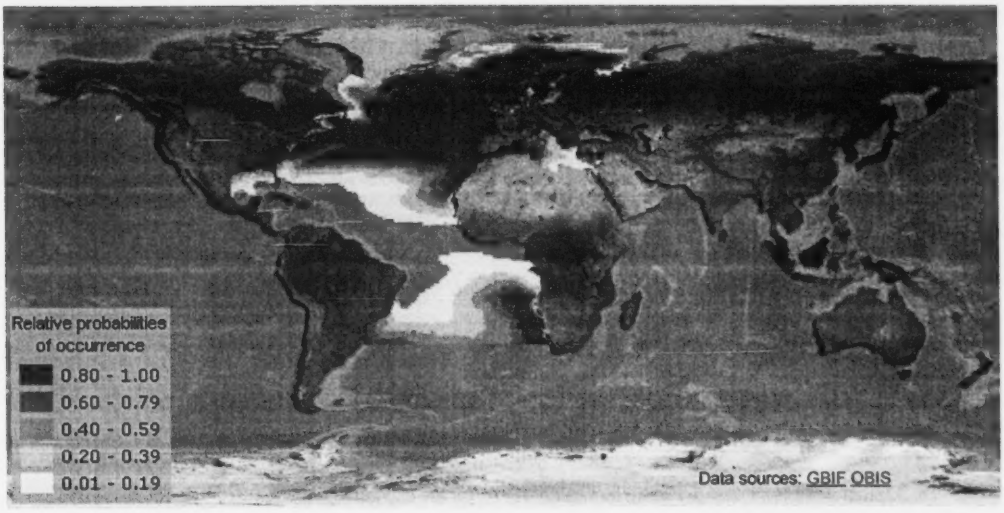


Figure 2: *Distribution of Atlantic saury (From: AquaMaps http://www.aquamaps.org/receive.php (Data sources: Global Biodiversity Information Facility and Ocean Biogeographic Information System [GBIF – OBIS]: http://data.gbif.org/species/ and http://www.iobis.org/)).*

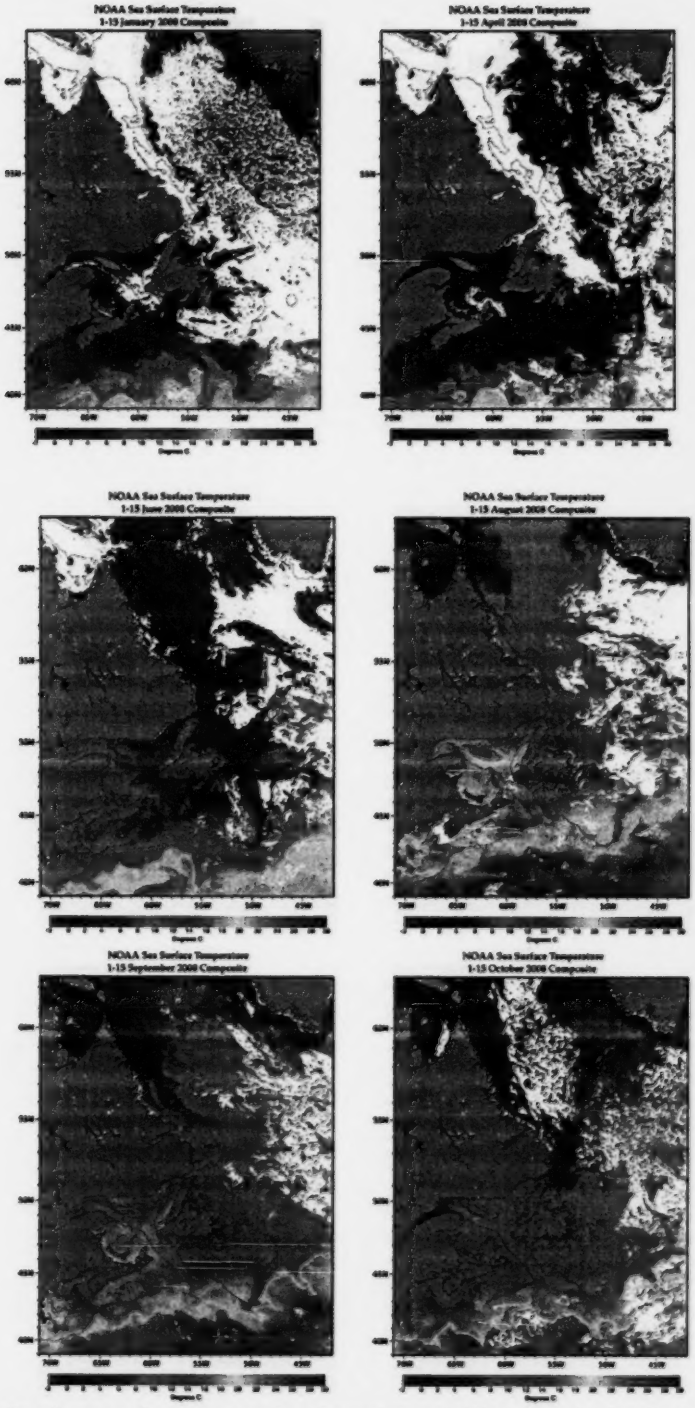


Figure 3: *Composite of sea surface temperature based on satellite telemetry for the first half of the month for January, April, June, August, September and October, 2008. Figures are from: http://www.mar.dfo-mpo.gc.ca/science/ocean/ias/seawifs/seawifs_3.html.*

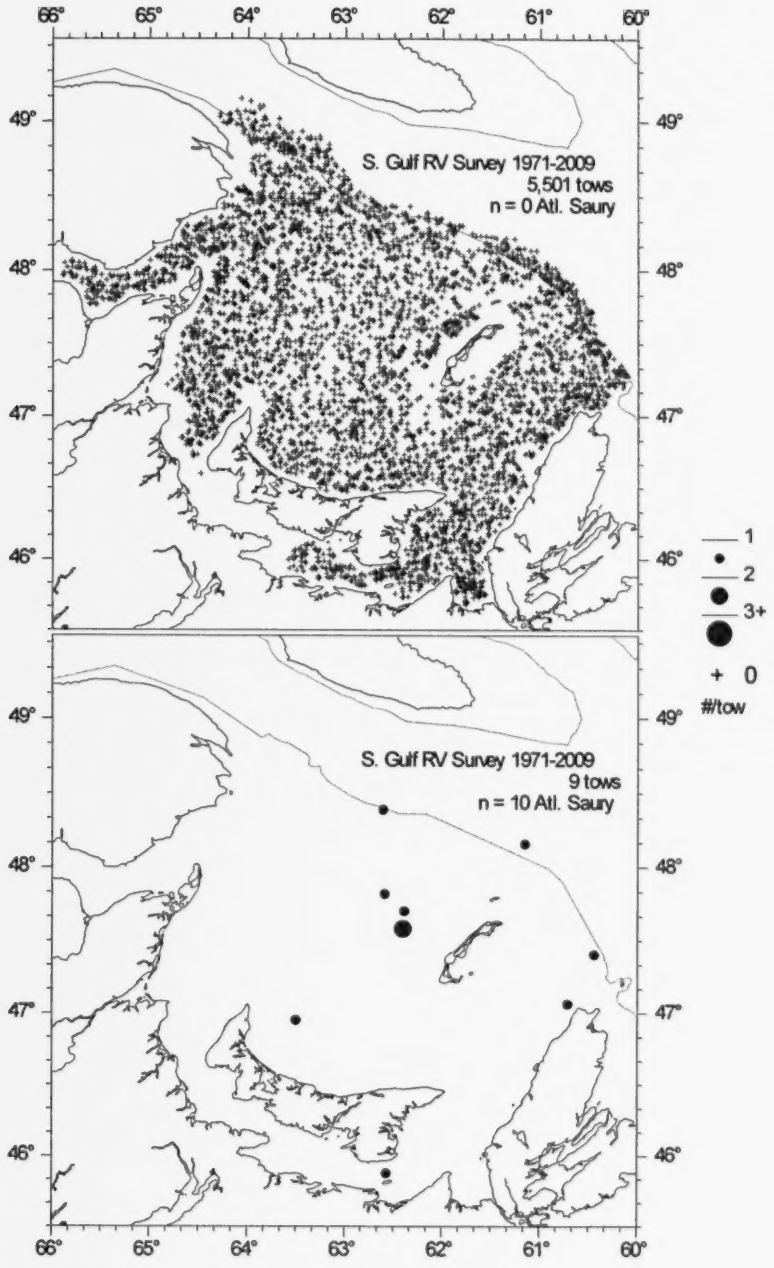


Figure 4: *Location of tows without Atlantic saury catches (upper panel) and location of tows with Atlantic saury catches (number) (lower panel) during the annual (Sept.) bottom-trawl survey of the southern Gulf of St. Lawrence (1971 to 2009).*

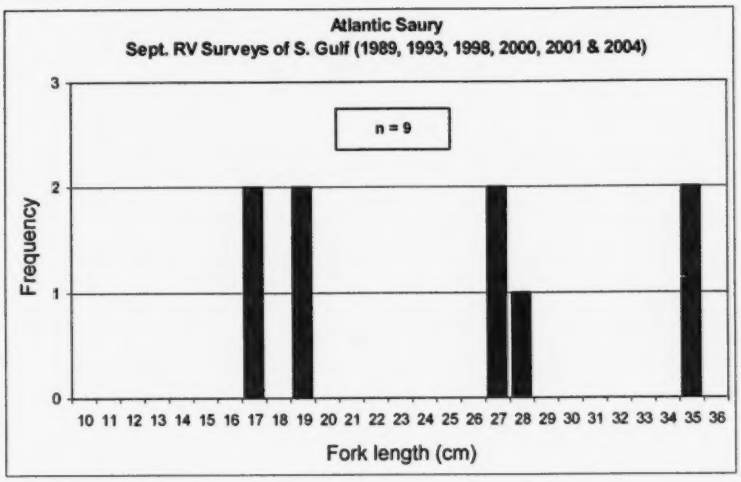


Figure 5: *Length frequency distribution of Atlantic saury captured in the annual (Sept.) bottom-trawl survey of the southern Gulf of St. Lawrence (1971 to 2009).*

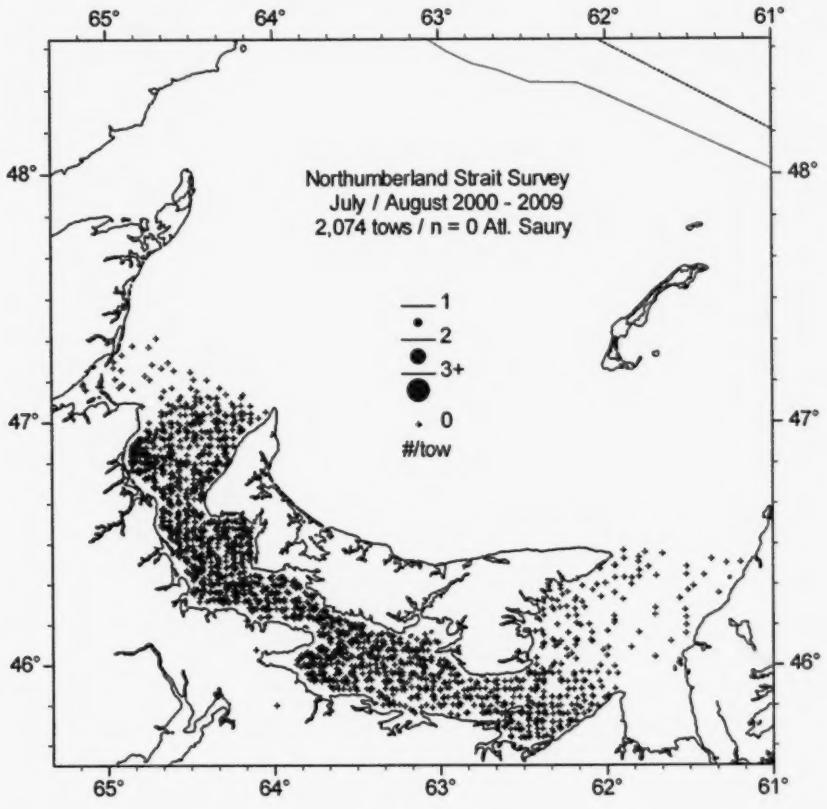


Figure 6: *Location of all tows during the annual (July/Aug.) bottom-trawl survey of the Northumberland Strait (2000 - 2009).*

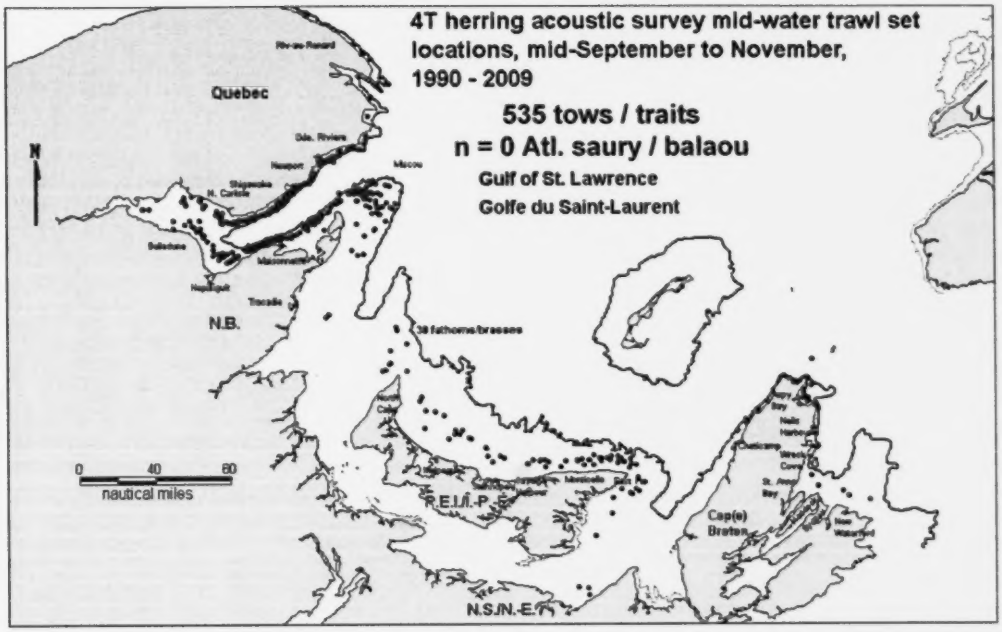


Figure 7: *Location of all mid-water trawl tows during the autumn herring acoustic survey of the Southern Gulf (NAFO Div. 4T; 1990 - 2009).*

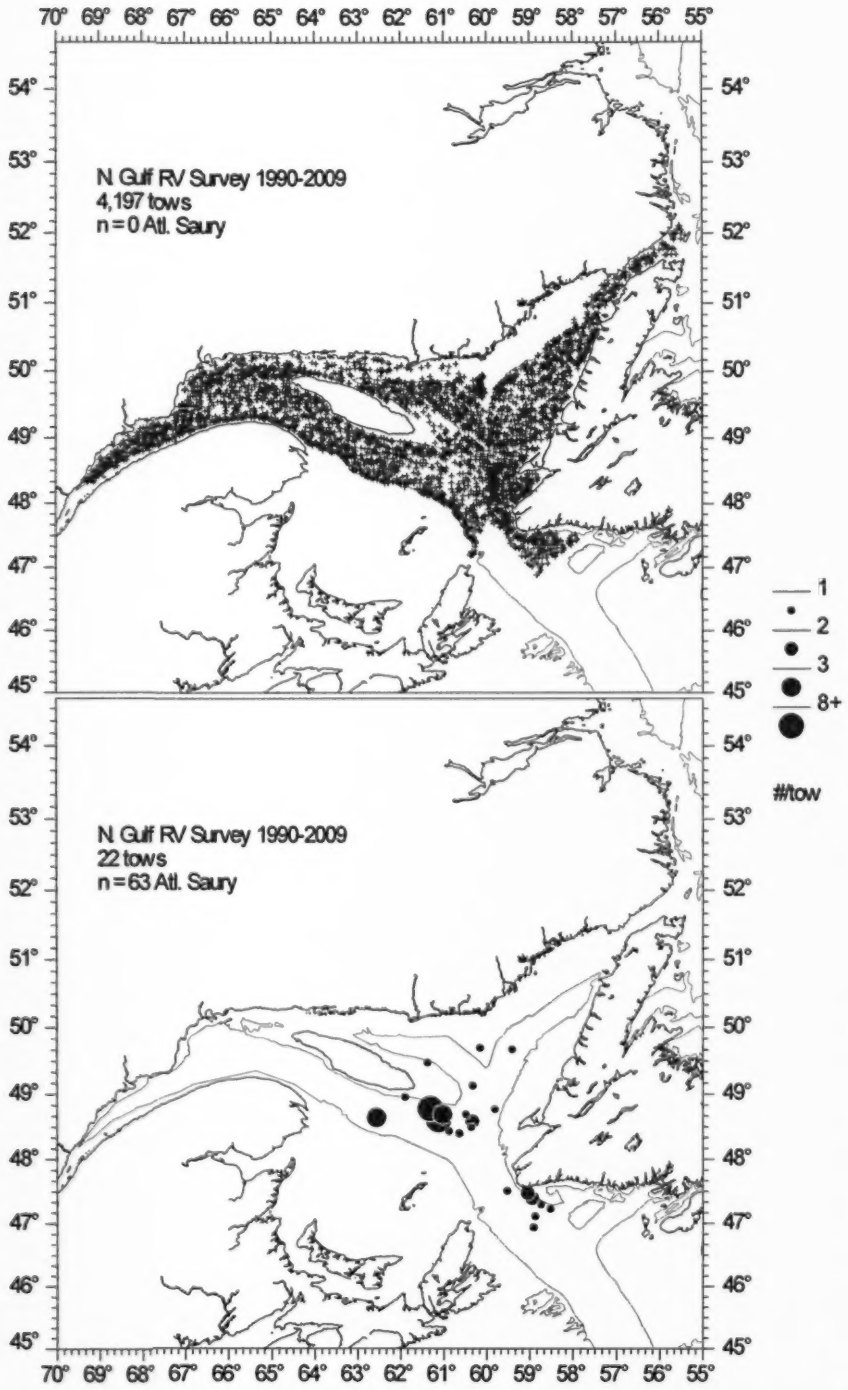


Figure 8: *Location of tows without Atlantic saury catches (upper panel) and location of tows with Atlantic saury catches (number) (lower panel) during the annual (Aug.) bottom-trawl survey of the northern Gulf of St. Lawrence (1990 to 2009).*

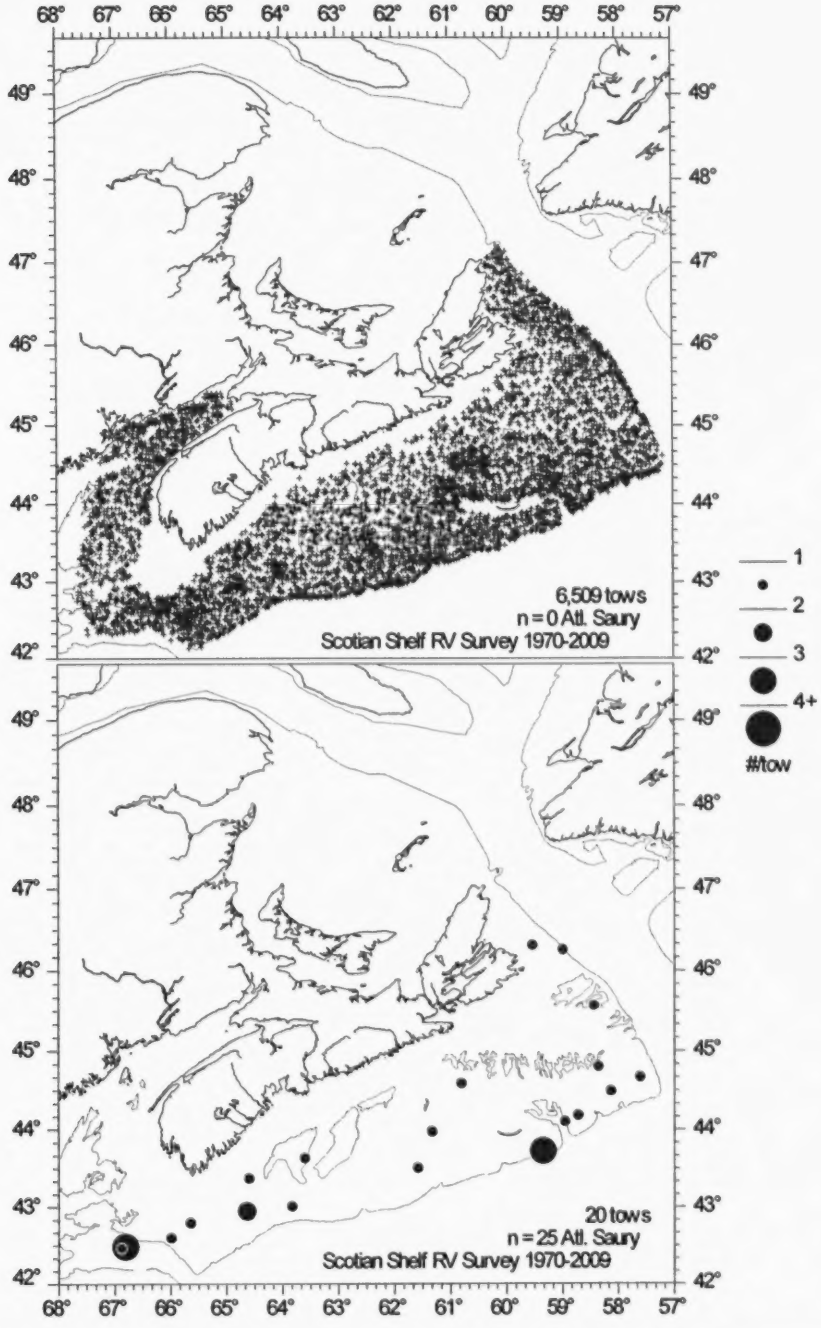


Figure 9: *Location of tows without Atlantic saury catches (upper panel) and location of tows with Atlantic saury catches (number) (lower panel) during the annual (July) bottom-trawl survey of the Scotian Shelf and Bay of Fundy (NAFO Div's. 4VWX and 5Zc; 1970 – 2009).*

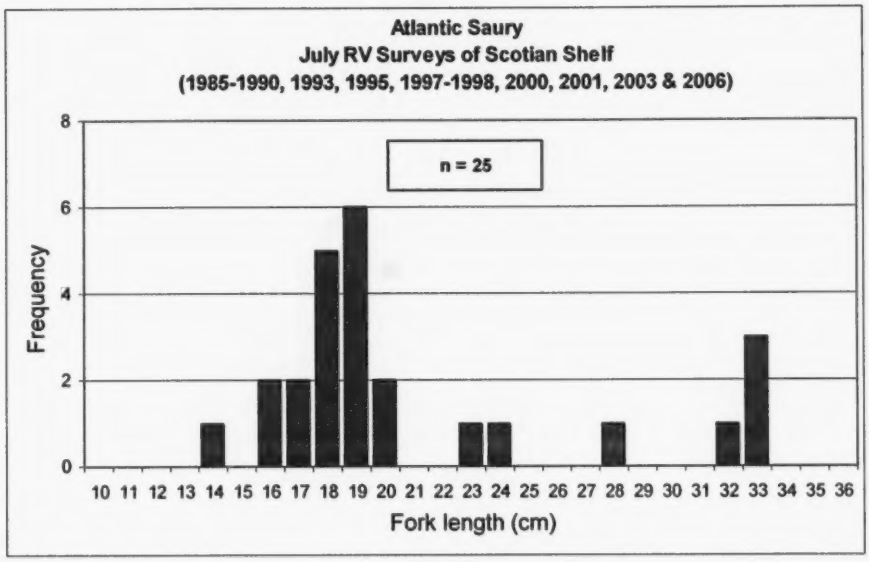


Figure 10: *Length frequency distribution of Atlantic saury captured during the annual (July) bottom-trawl survey of the Scotian Shelf and Bay of Fundy (NAFO Div's. 4VWX and 5Zc; 1970 – 2009).*

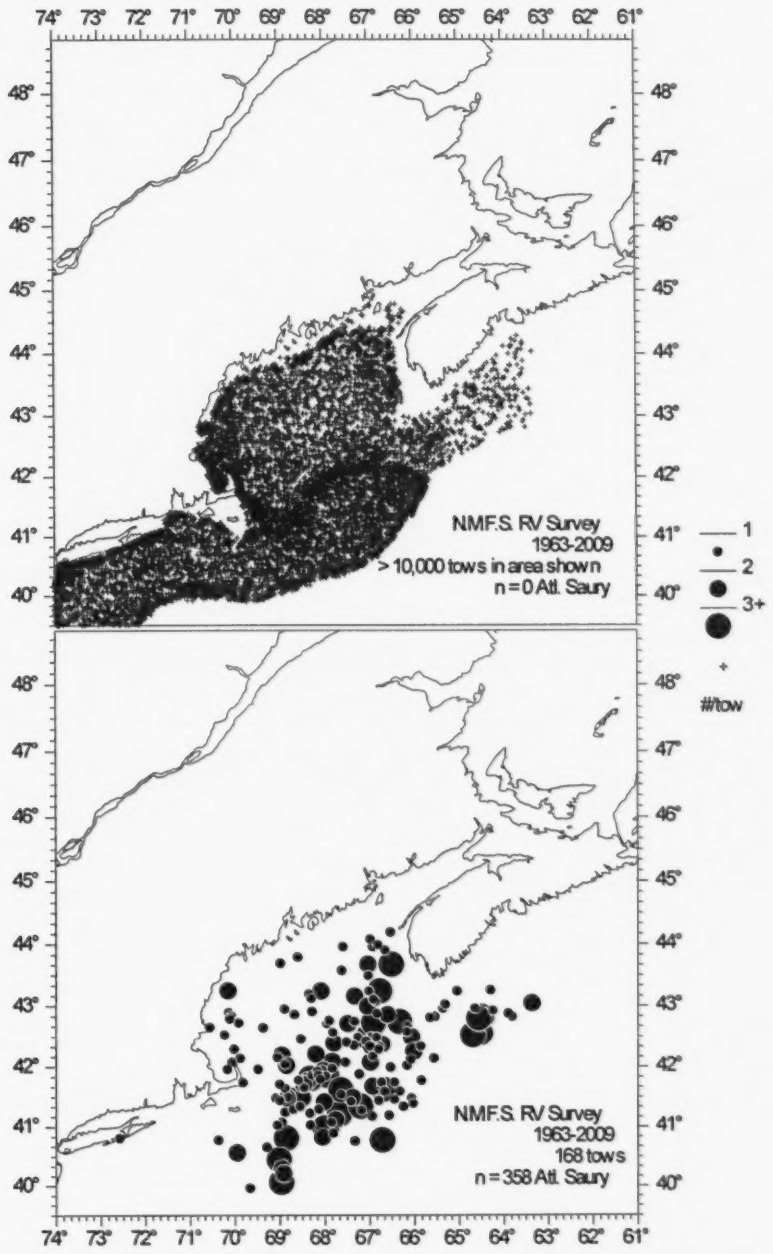


Figure 11: *Location of tows without Atlantic saury catches (upper panel) and location of tows with catches (number) of Atlantic saury (lower panel) during the National Marine Fisheries Service (US) annual fall bottom-trawl survey of the eastern seaboard (NAFO Div's. 4X, 5YZ and 6ABCDE; 1963 – 2009).*

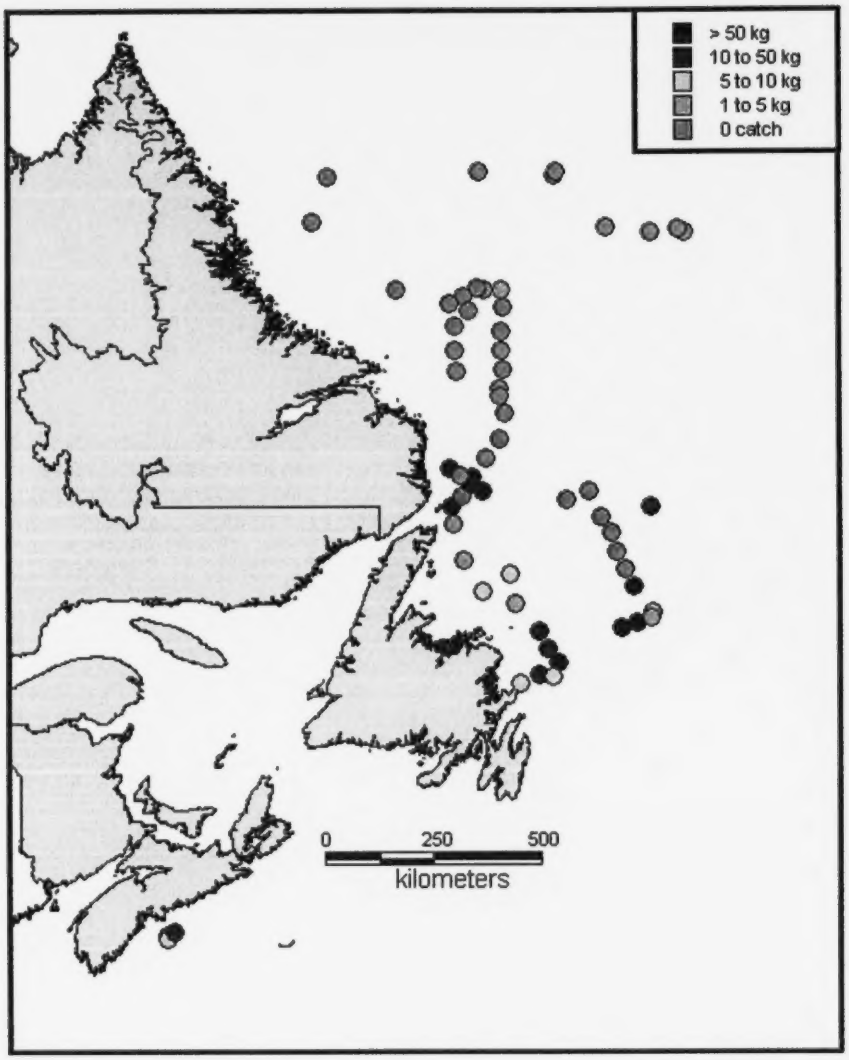


Figure 12: *Locations of pelagic surface trawl tows during the August 2008 and September 2009 SALSEA pelagic ecosystem survey of the northwest Atlantic and corresponding catches (kg) of Atlantic saury.*

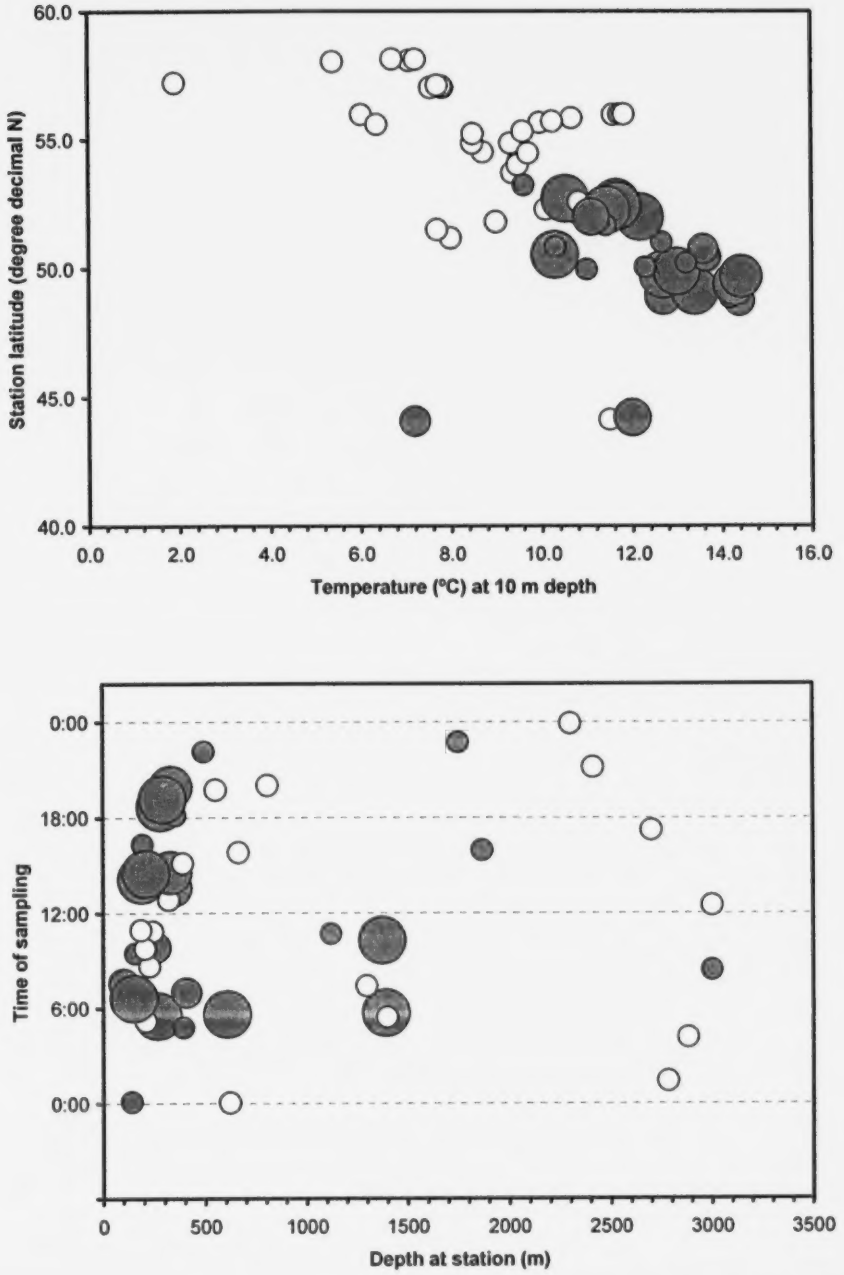


Figure 13: *Catch categories (kg) of Atlantic saury relative to latitude and temperature at station (upper panel) and relative to time of day and depth of station sampled (lower panel) in August 2008 and September 2009. Catch categories (size of bubble) are 0 catch (white symbols) and five bubble sizes (from smallest to larges)t of:<5 kg, 5 to 10 kg, 10 to 25 kg, 25 to 50 kg, > 50 kg.*

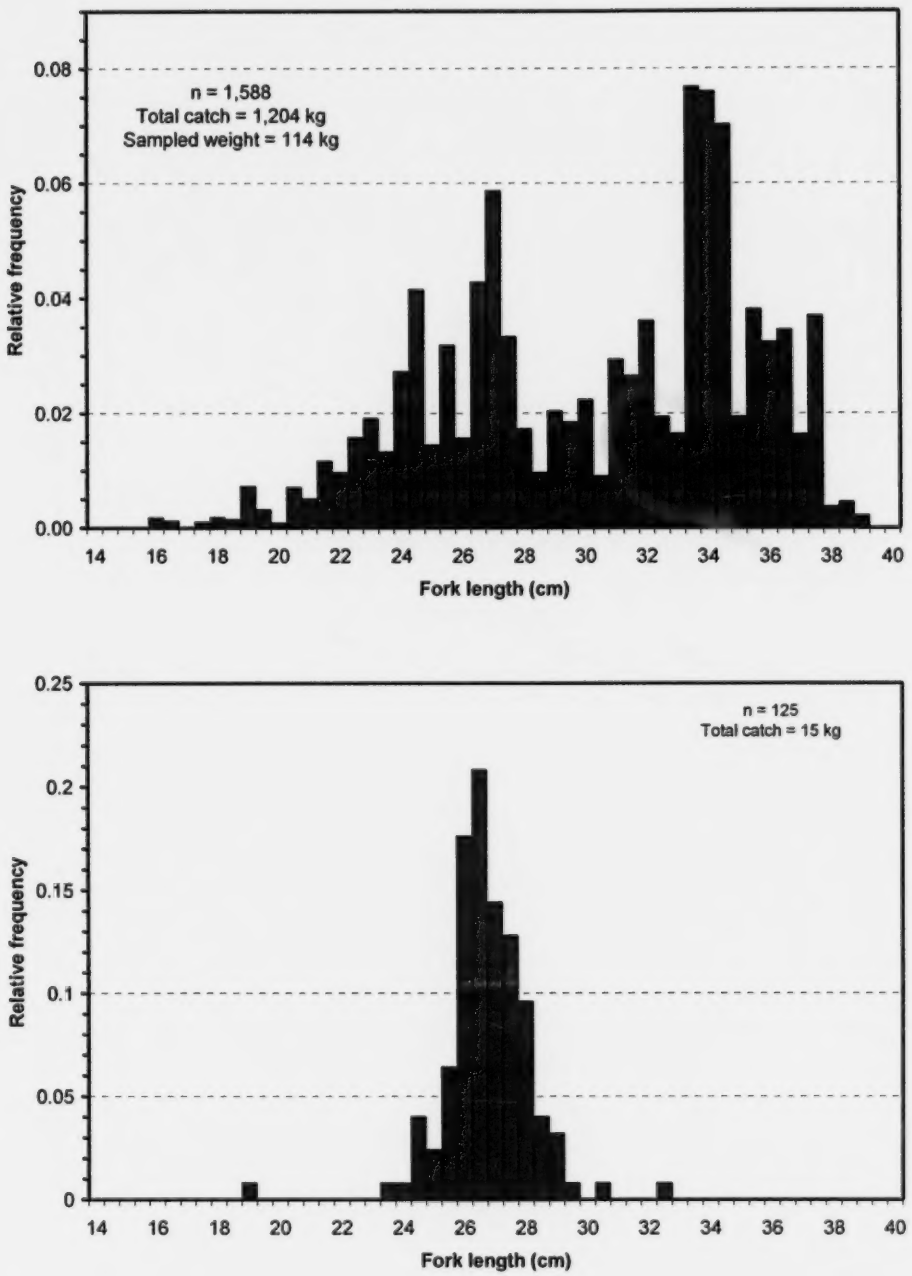


Figure 14: *Catch-weighted length frequency distributions of Atlantic saury sampled in August 2008 (upper panel) and September 2009 (lower panel) during the SALSEA pelagic ecosystem survey of the northwest Atlantic.*

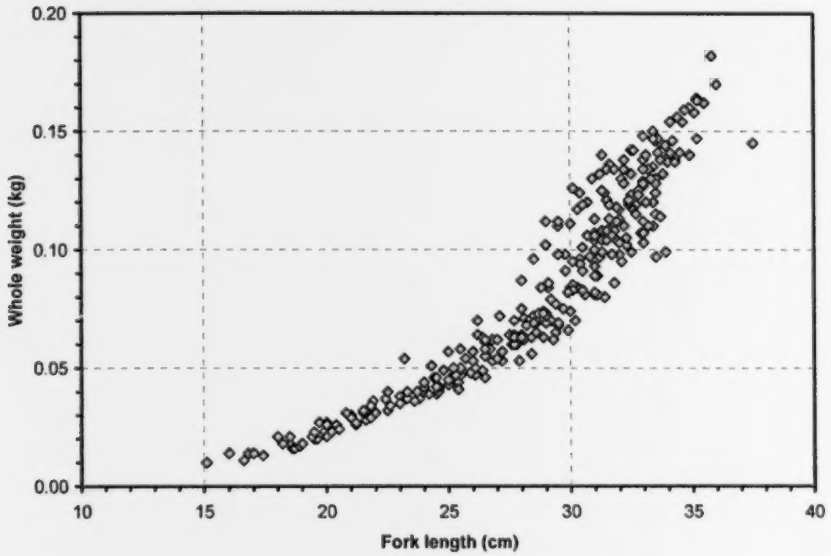


Figure 15: *Length-weight relationship of Atlantic saury sampled in August 2008 in the northwest Atlantic.*

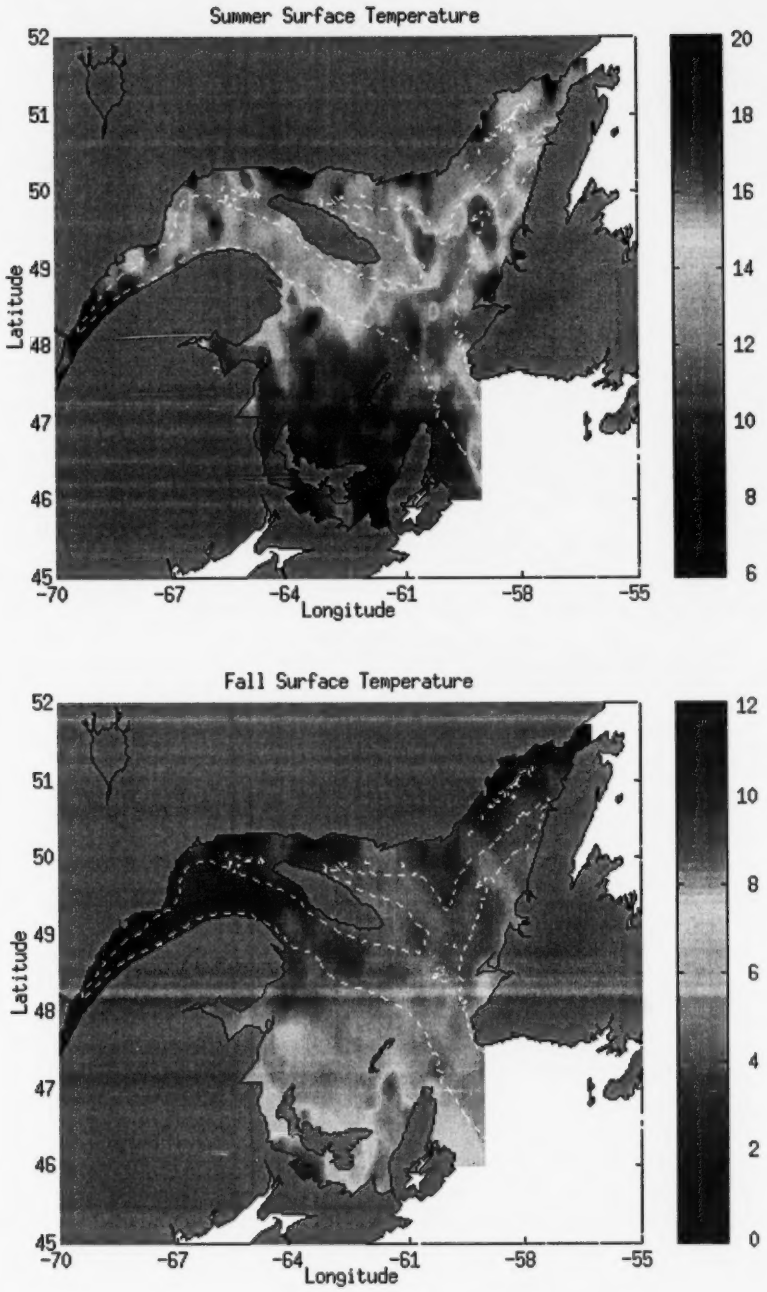


Figure 16: *Composite summary of sea surface temperatures by season (summer, fall) for the Gulf of St. Lawrence in 2008. Figures are from: http://www.mar.dfo-mpo.gc.ca/science/ocean/gsl/gslmap.html.*

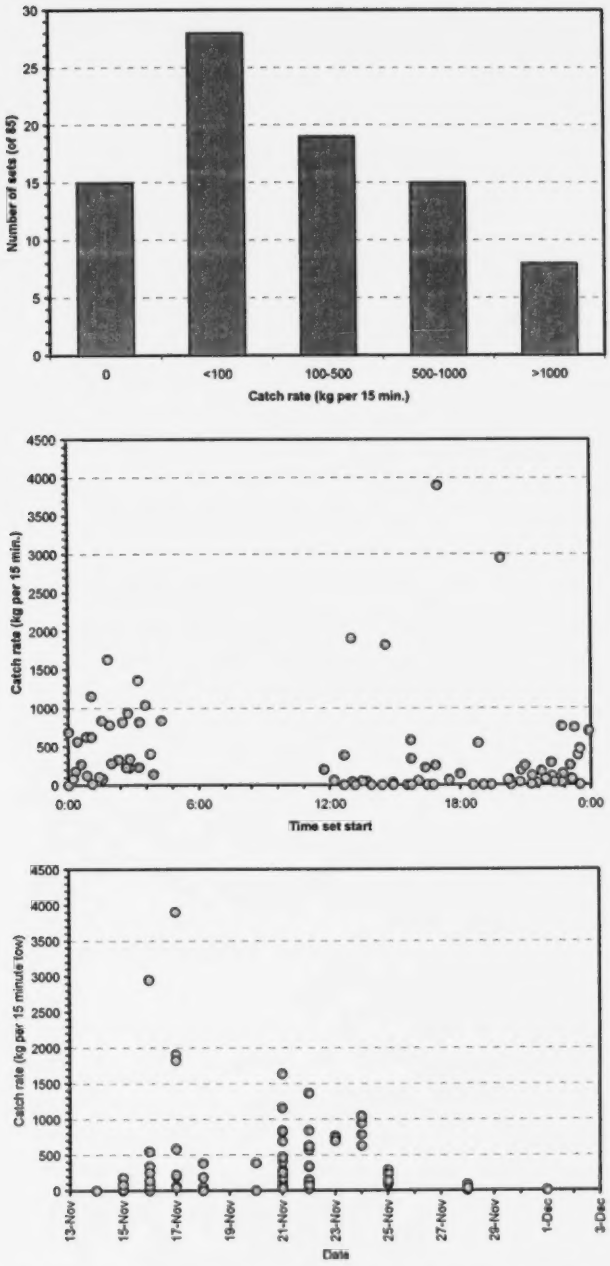


Figure 17: *Catch rate information in terms of a) frequency, b) relative to time of day and c) relative to date of fishing during the exploratory Atlantic saury fishery in Aulds Cove, NS, 1995.*

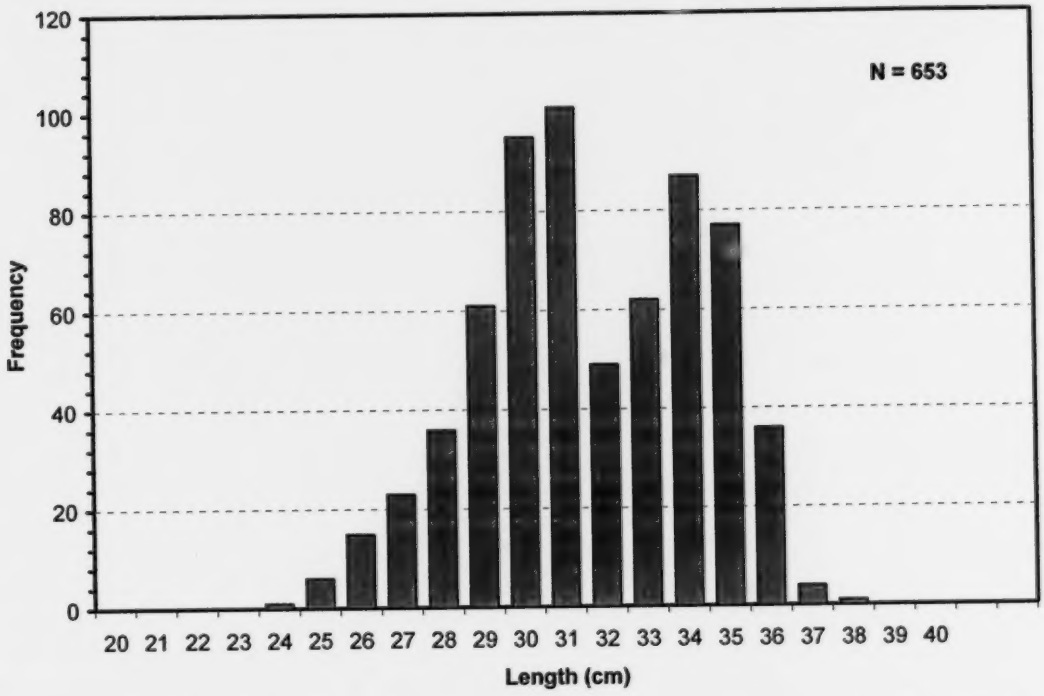


Figure 18: *Length frequency data of catches from six sets during the 1995 exploratory fishery in Aulds Cove, NS.*

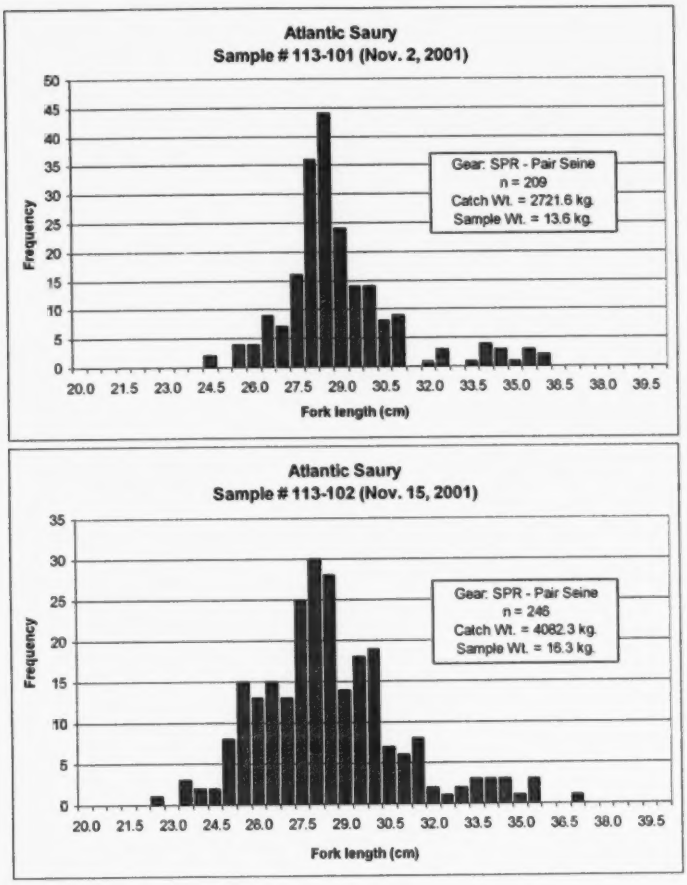


***Figure 19:**. Length frequencies of Atlantic saury landed in Aulds Cove, NS in Nov. 2001.*